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DEMOGRAPHIC CONSEQUENCES OF MANAGING FOR FLORIDA SCRUB-JAYS (*APHELOCOMA COERULESCENS)* ON AN ISOLATED PRESERVE.

by

CASEY LYON
B.S. University of Florida, 1999

A thesis submitted in partial fulfillment of the requirements
for the degree of Master of Science
in the Department of Biology
in the College of Sciences
at the University of Central Florida
Orlando, Florida

Summer Term
2007

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ABSTRACT

Many species naturally occupy discrete habitat patches within a mosaic of habitats that vary in quality. The Florida scrub-jay (*Aphelocoma coerulescens*) is endemic to Florida scrub, a habitat that is naturally patchy and greatly reduced in area over recent decades owing to development and urbanization. Because of this habitat loss, future management of Florida scrub-jays will focus on smaller, fragmented tracts of land. My study examines such a tract, Lyonia Preserve, southwest Volusia County, FL. This preserve was unoccupied by scrub-jays prior to habitat restoration. The preserve is now frequently managed exclusively for scrub-jays as a habitat island surrounded by development. Management of the preserve includes roller chopping, root raking, timbering, and “oak stripping” where islands of oak patches are left intact while the rest of the area is roller chopped. I investigate what, if any, demographic consequences may be associated with the habitat management and the spatial setting of the preserve. I used population data collected in this area since 1992 to examine population growth and responses to habitat restoration within the preserve and habitat destruction outside the preserve. I mapped territories and measured survival and recruitment of scrub-jays, and dispersal into and out of the study area, for two and a half years. Since restoration, the population has shown logistic growth, with the area supporting higher than average densities of scrub-jay family groups. Observed density of the population and territory size varied between study years. Breeder survival values were positively related to territory size and significantly lower during periods of highest observed density. However, recruitment (yearling production) showed no relationship to territory size. Dispersal to isolated habitat patches was observed; likewise, several failed dispersal events were noted. No immigration into the study area was observed; however these data may be underrepresented

since not all scrub-jays in and outside of the preserve were banded, and data collection was limited during the initial colonization period. High densities inside the preserve may therefore be both a result of frequent habitat management in the form of mechanical treatment as well as crowding of individuals due to outside habitat destruction. The results indicate that carrying capacity of habitat for scrub-jays may be raised by frequent, mechanical management; however, if the area is isolated, management may result in high densities and negative demographic consequences, e.g., reduced breeder survival. Negative effects of management may be avoided by subjecting smaller areas to mechanical treatment with increased time between treatments. Land managed for Florida scrub-jays should be contiguous or connected with other scrub habitats so that surplus birds from the managed areas have a refuge and do not contribute to increased densities. Regulatory officials should use caution when allowing for “take” of scrub-jay habitat as the effects may extend beyond the local habitat being destroyed.

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To my husband Andrew, who supported me during this venture, to my parents who never questioned how long this project would take, to my grandparents who instilled in me a love of the outdoors, and to my son Aidan who is my greatest inspiration and whom I hope will always live in a world with Florida scrub-jays.

ACKNOWLEDGMENTS

This study was funded by Volusia County Environmental Management (VCEM). I would especially like to thank from VCEM Stephen Kintner, who always made sure that I had funding; Ginger Adair, who allowed me the time to finish data collecting; Kellie Steward; for all her help with all things GIS related; and Katrina Locke, who started up this project and whose passion for all things scrub is infectious. I would have never known that this project existed if it weren't for the early guidance of Dr. John Weishampel. Many thanks to Keith Clanton, formerly of Seminole State Forest who got the initial banding activities started. I would like to thank Christopher Valligny, formerly of Archbold Biological Station, for working with VCEM and I to band scrub-jays in Volusia County. I could never have collected all the data without being subpermitted under Dr. Reed Noss who, with his wife Myra Noss, came out on their own time to assist with this project. Sumita Singh, thank you so much for always making sure my banding permits and paperwork were in order. Megan Keserauskis, thank you for all your help and support over the years, I hope I can pay you back someday. And most of all, I would like to thank Dr. I. Jack Stout, who took me into his Ecology lab and became my mentor those many years ago.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS/ABBREVIATIONS

FFWCC	Florida Fish and Wildlife Conservation Commission
FLUCCS	Florida Land Use, Cover and Forms Classification System
FNAI	Florida Natural Areas Inventory
IACUC	Institutional Animal Care and Use Committee
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Society
VCEM	Volusia County Environmental Management

INTRODUCTION

Populations of most species in nature typically occupy a range of habitats that vary in quality within the landscape (Howe et al. 1991, Watkinson and Sutherland 1995). However, some species occupy discrete habitat patches within the range of habitats in the local region (Pulliam 1988). The term metapopulation was introduced by Levins (1969) and suggests a population of subpopulations within these habitat patches, with colonization and extinction of discrete breeding subpopulations connected by migration or dispersal (Hanski and Simberloff 1997). Size and growth rate of subpopulations within metapopulations may vary as a result of the different habitat types available (Pulliam 1988, Pulliam and Danielson 1991). Pulliam (1988) determined that these different habitat types could be divided into two groups: sink habitats, where mortality is greater than reproduction, and source habitats, where reproduction is greater than mortality. Populations in sink habitats would be connected via dispersal to populations in the source habitats and would in fact be maintained by dispersal from the source (Pulliam 1988). If connectivity is lost, the sink population would in time become extinct, consequently the spatial arrangement of source and sink habitats in a landscape may strongly influence whether the metapopulation ultimately survives (Noss et al. 1997).

With many landscapes becoming increasingly fragmented by anthropogenic alterations, some metapopulations occur in environments where their long-term viability is threatened (Hanksi 1991). Habitat fragmentation involves complex ecological processes, including the potential loss of critical resources for breeding and survival (Gardner and Heinsohn 2007), suggesting that fragmented landscapes may be dominated by sink habitats (With and King 2001). Metapopulation theory is often used to describe these effects of fragmentation on the biology of declining species (Harrison 1991) and has become a major paradigm in conservation biology (Stith et al. 1996).

Florida scrub habitat has provided many opportunities to examine source-sink dynamics for both plants (Quintana-Ascencio and Menges 1996) and animals (Breininger et al. 1995, Hokit et al. 2000). This unique system naturally exists as an archipelago of habitat islands surrounded by habitats unsuitable for obligate scrub organisms (Hokit et al. 2000). In addition to the natural patchy occurrence of scrub, it is maintained by low frequency, high intensity fire (Myers 1990) and the organisms that have evolved there are under selective pressure from this disturbance regime (Greenburg et al. 1995). Florida scrub habitat is a highly endangered ecosystem (Noss et al. 1997), and the loss of this habitat may jeopardize the long-term survival of species evolved to live in scrub through a reduction of resources and dispersal success (Stith et al. 1996). The remaining patches are fragmented and therefore may lack the necessary fire management, further threatening obligate scrub organisms with extinction (Root 1998).

Florida scrub-jays (*Aphelocoma coerulescens*) are endemic to various forms of Florida scrub (Wescott 1970) and state (Florida Administrative Code Chapter 68A) and federally listed as threatened (Federal Registrar 1987). Formerly occurring in most counties of peninsular Florida, the scrub-jay has been extirpated from nine counties and declines of 50% or more have occurred in key portions of its range (Stith 1999). Florida scrub-jays are long-lived cooperative breeders, with the young delaying breeding for at least one year to participate in predator detection, territory defense, and care of offspring with the breeding pair (Woolfenden and Fitzpatrick 1984). Each family group defends an exclusive territory throughout the year that is used for both foraging and breeding (Woolfenden and Fitzpatrick 1984). Territories average 10 ha in optimal habitat and may be larger where habitat is suboptimal (Woolfenden and Fitzpatrick 1984, Woolfenden and Fitzpatrick 1991, Breininger et al. 1995).

Because Florida scrub-jays maintain year-round territories, they have been excellent candidates for empirical studies of metapopulation dynamics (Stith et al. 1996), including source-sink analyses (Breininger et al. 1995, Breininger and Carter 2003, Breininger and Oddy 2004). Net reproduction must equal or exceed net mortality without immigration within a scrub-jay territory in order for the territory to be a source (Breininger and Carter 2003). Source scrub-jay habitats are generally those that have ≥ 50% scrub oak cover, ≥ 20% open space (sand or herbaceous cover < 15cm tall), < 15% pine cover, with a mean shrub height of 1.2 to 1.7m (Breininger 1992, Duncan et al. 1995).

Maintaining local population viability of scrub-jays has in the past required management of habitat using prescribed fire because most landscapes are too fragmented for natural fire regimes to occur (Breininger et al. 1999, Duncan and Schmalzer 2004). The disruption of natural fire regimes by fragmentation of scrub habitat can greatly magnify the impacts of habitat loss for Florida scrub-jays (Breininger et al. 2006) in the form of juvenile recruitment (Breininger 1999), as the fragmented habitat commonly transitions to unsuitable woodland habitat (Breininger et al. 1995). Fragmentation of habitat has been demonstrated to affect juvenile recruitment in urban populations of red-wing blackbirds and rufous treecreepers due to increased predation (Vierling 2000 and Luck 2002, respectively).

As scrub habitat in Florida declines in area and becomes more fragmented, there will be a need to manage scrub-jays in smaller, fragmented habitat with a strong suburban/urban interface. The objective of my study is to use the source-sink model at the scale of territories to examine potential demographic effects of managing scrub-jays in discrete habitat islands surrounded by development. My study focuses on a population of scrub-jays that existed at known high densities (average territory size less than 10 ha) post habitat restoration (Epperson and Romogosa 2001). My predictions are: (1) appropriate habitat management can raise the carrying capacity of a preserve for scrub-jays, (2) habitat destruction outside of a preserve will increase immigration substantially and cause the population to overshoot carrying capacity, and (3) the resulting increase in population density will result in reduced reproductive success. This case study will provide important data for future mitigation planning in conservation banks and isolated preserves.

METHODOLOGY

Study Area

My study was conducted on the 145 ha Lyonia Preserve and adjacent habitat in the middle of the City of Deltona, 48 kilometers inland from the Atlantic Ocean in Volusia County, Florida. Lyonia Preserve is completely surrounded by suburban and commercial development and high-traffic roads. It is heavily used by pedestrians who often illegally bring food into the Preserve to feed scrub-jays (pers. observation).

The preserve is found in the Central Lake District of southwest Volusia County (Brooks 1982); a karst region characterized by undulating hills that support inland sand pine scrub habitat (Brown et al. 1990). Elevations in the general area range from 6 to 34 m above sea level (www.ci.deltona.fl.us). The density of the sand pines (*Pinus clausa*) and the height of the canopy in sand pine scrub habitat can vary greatly; however, approximately 90% of the shrub layer in this habitat type is made up of the same few species (Myers 1990). At Lyonia Preserve these species include myrtle oak (*Quercus myrtifolia*), saw palmetto (*Serenoa repens*), sand live oak (*Q. geminata*), Chapman's oak (*Q. chapmanii*), rusty lyonia (*Lyonia ferruginea*), and Florida rosemary (*Ceratiola ericoides*).

Climate of the study site is characterized by hot summers and mild winters. The highest monthly mean daily temperature of 32 ^{o}C occurs in August and the lowest 10 ^{o}C in January (www.ci.deltona.fl.us). Annual precipitation averages 135 cm, with the rainy season generally extending from June – September (www.ci.deltona.fl.us). During the time of my study, several extreme weather events occurred. The 2004 hurricane season was one of the most active seasons since 1995, with the most significant storms all making landfall in Florida (Hovis 2005). Hurricane Charley made landfall on the southwest coast of Florida near Captiva August 13th with maximum sustained winds near 240 km/hour, spawning off nine tornados (two in Volusia County) before exiting the northeast coast near Daytona Beach August 14th with maximum sustained winds of 120-130 km/hour (Pasch et al. 2005). Hurricane Frances made landfall on the eastern coast of Florida over Hutchinson Island September 4th with maximum sustained winds of 157-167 km/hour, spawning 23 tornados in Florida before exiting into the northeastern Gulf of Mexico near New Port Richey on September 6th (Beven 2004). Hurricane Jeanne made landfall on the eastern coast of Florida again over Hutchinson Island on September 26th with maximum estimated winds of 194 km/hour, and exited into central Georgia (Lawrence and Cobb 2005). Beginning April 2006 through May 2006 most of the state of Florida (including the study area) experienced abnormally dry periods, and by June 2006 had entered into a moderate drought (www.drought.unl.edu/dm/monitor). Figure 1 shows the amount of rainfall experienced by two cities geographically close to Lyonia Preserve during the study time.

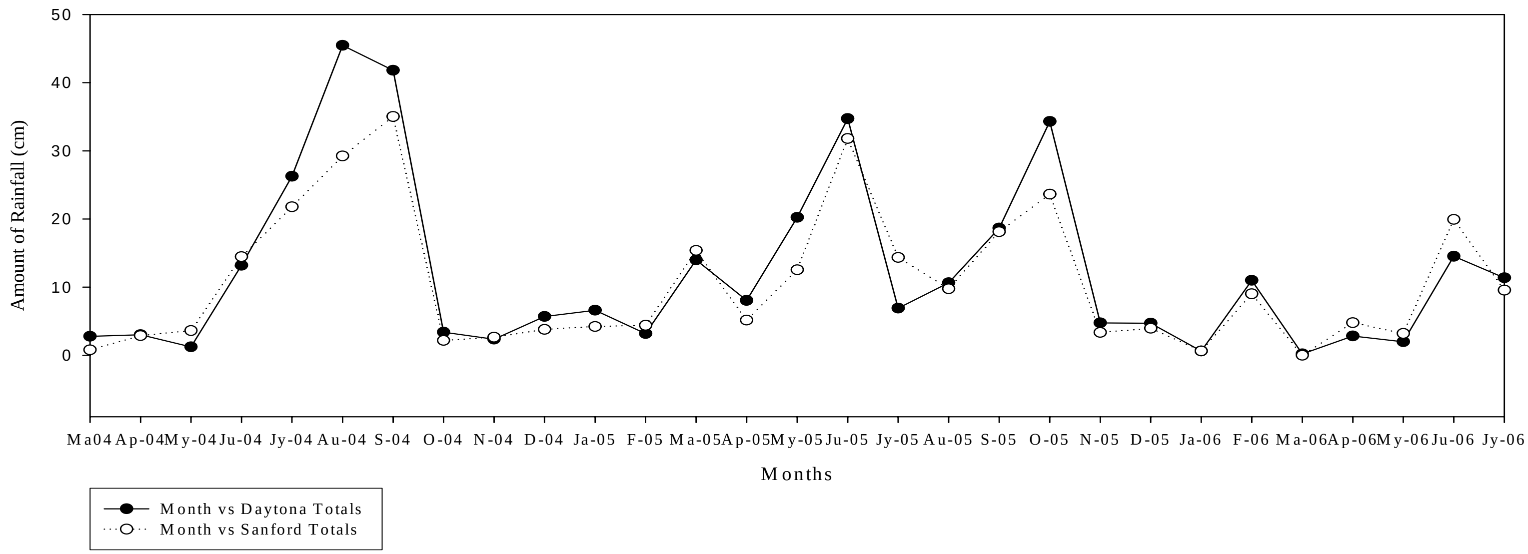

Figure 1: Monthly rainfall totals for two cities near Lyonia Preserve, Deltona, Florida.

Lyonia Preserve is divided into three management Phases (Figure 2) and is currently utilized as a Florida scrub-jay conservation bank for impacts to occupied scrub-jay habitat made by the County of Volusia and the Volusia County School Board. A conservation bank typically comprises a tract of land managed to restore, enhance, and protect a listed species' habitat with the purpose of making units of habitat value available for sale to third-party project applicants who need to compensate for impacts to listed species that would result from their projects (USFWS 2006 Federal Registrar). Prior to habitat management, the site was dominated by a closed canopy of mature sand pines. Habitat management began in February 1994 with timber harvesting completed throughout Phase 1 and 2 in March 1994. In addition to the timber harvest, root raking methods produced trails, fire breaks, and circular clearings in Phase 1. One quarter of Phase 1 was burned in April 1994. Another one quarter of Phase 1 was stripped roller chopped in a north-south pattern to create approximately 30 m wide strips that were separated by intact strips also 30 m wide. Phase 3 remained in a mature sand pine canopy state during this time. A prescribed fire was conducted in the southeast management unit in April 1994. All initial management activities were completed by August 1994. In 2003, just prior to the onset of this study, a large area was double roller chopped in Phase 1 and Phase 2. In the late fall of 2004, a timber harvest occurred around the edges of Phase 2 and throughout most of Phase 3 to salvage hurricane debris in the form of fallen sand pines. During the winter of 2004, areas in Phase 1 and Phase 2, as well as areas along the adjacent powerlines, were roller chopped to create a stripping effect, leaving oak islands. No additional habitat management occurred in the study period.

Figure 2: Location and area of the three management phases at Lyonia Preserve, Deltona, Florida.

Previous Lyonia Preserve and Southwest Volusia County Florida Scrub-jay Surveys

Prior work provided qualitative and quantitative evidence of scrub-jay utilization in and around the study area. Surveys conducted on Lyonia Preserve prior to habitat restoration found no scrub-jays utilizing the site (Young and Palmer 1992). Statewide mapping for Florida scrub-jays performed in 1992-1993 make no mention of any occupation of the area that was to become Lyonia Preserve; however, it does show several large areas of occupation within dispersal distance to the Preserve, including 24 families on the privately owned Stewart Ranch (Fitzpatrick et al. 1994). Stewart Ranch has since become the housing development of Arvida, providing habitat for only one known scrub-jay family (NeSmith et al. 2004). A survey of Lyonia Preserve performed in 1995 found 18 scrub-jays in six families in the post management setting (Richardson 1996). A second survey performed in 2000 found 88 scrub-jays in 20 families, with an average territory size of 5.04 ha and 4.4 family members (Epperson and Romagosa 2001). These jays were occupying Phase 1 and 2, but not Phase 3.

Banding Efforts

Banding activities were authorized by permits from the USFWS (TE 080628-2), FFWCC (WB 04031b), USGS (Permit # 21401), and the University of Central Florida Institutional Animal Care and Use Committee (IACUC). Those Florida scrub-jays that were not banded under the above mentioned permits were banded in a cooperative effort with the Florida Department of Forestry and Archbold Biological Station. Banding efforts began in December 2003. Scrub-jays were captured by baiting Potter traps and drop traps with peanuts. Once captured, each jay was fitted with a uniquely numbered aluminum USGS band and three celluloid color bands, and then released at the point of capture. It was not possible to band all the jays, despite efforts to do so. Every family of scrub-jays in the study area had at least one family member banded, and in most cases multiple family members were banded. Several scrub-jays outside of Lyonia Preserve were also banded by myself and Archbold Biological Station.

Once a scrub-jay was able to be individually identified it was classified by sex, status (breeder or helper), and age (hatch year, second year or one year old, after hatch year, or after second year). I determined sex and status by the following criteria: (1) sex-specific vocalizations and stereotypic postures of females during territorial displays (Woolfenden and Fitzpatrick 1984); (2) vocalization response of breeding males to the above-mentioned breeding female displays (C. Valligny pers. comm..); (3) conspicuous male-female pairs that defended an exclusive territory and that potentially or actually nested (Mumme et al. 2000); (4) observation of a brood patch or incubation behaviors of females during the breeding season since only females incubate (Woolfenden and Fitzpatrick 1984); and (5) dominance interactions in which males dominate females and breeders dominate same-sex nonbreeders (Woolfenden and Fitzpatrick 1977). I classified birds into age categories based on plumage and coloration of inside the mouth (see Pyle 1997).

Territory Mapping and Censusing

I identified family groups beginning March 2004 at the onset of breeding season (March - June, Woolfenden and Fitzpatrick 1984) by censusing following protocols established by Fitzpatrick et al. (1991), since suburban scrub-jays breed earlier than their wildland counterparts (Schoech 1996). Once I identified the family groups they were censused once a month beginning March 2004 and ending November 2005. Censusing resumed in March 2006 and continued until August 2006. During the monthly census, I checked roads adjacent to Lyonia Preserve for any evidence of scrub-jay road mortality. I mapped territories in Lyonia Preserve as well as immediately adjacent habitat (including powerlines and urban areas) each July since the young of the year are independent (Woolfenden and Fitzpatrick 1984) of 2004, 2005, and 2006, following protocols adapted from Fitzpatrick et al. (1991). I defined territorial boundaries by recording the limits of scrub-jay movement and territorial disputes in the field with a hand held Magellan GPS unit. I created territory maps and calculated areas using ArcView 3.3 (1992-2002). Final maps for this study were produced in ArcView 9.2 (1999-2006).

Habitat Quality

I calculated areas that underwent habitat management prior to and during the course of my study using ArcView GIS 9.2. I performed ground-truthing evaluations of two randomly selected territories for management Phases 1 and 2 using a modified point intercept methodology following Breininger et al. (1995). I utilized territories mapped in Study Year 2 for these evaluations, after the final event of habitat management had occurred for the study period. From the geographic center of each territory 8 lines were originated at 45 degrees. Along each line every 10 m a measurement was taken of habitat, with four points along each line. These measurements included scrub oak cover, pine cover, amount open space, and height of scrub oak vegetation. I expressed these data as a percentage and compared with Habitat Suitability Indices (HSI) established for the Florida scrub-jay, with a value of 1 being the most suitable habitat (Breininger 1992).

Dispersal Within and Outside of Lyonia Preserve

I calculated dispersal distances and frequencies between the sexes since female scrub-jays generally disperse farther than males (Woolfenden and Fitzpatrick 1984). I calculated average territory width (using data from all three mapping events) in an attempt to generalize dispersal distance within the study area. Scrub-jays that inherited a territory dispersed a distance of 0. Scrub-jays that budded off from the natal territory dispersed a distance half the average territory width. Actual dispersal distances for scrub-jays that permanently emigrated from Lyonia Preserve were recorded and not generalized. These distances were represented as a straight line and do not represent any wandering that may have occurred during dispersal.

I used maps of known and potential scrub-jay habitat (NeSmith et al. 2004) to target areas for censusing at least once a year to document any dispersal of Lyonia Preserve scrub-jays.

These maps are a result of a study performed by Florida Natural Areas Inventory (NeSmith et al. 2004). I identified other potential habitats utilizing Florida Land Use, Cover and Forms Classification System (FLUCCS) vegetation codes provided by Volusia County Property Appraiser's website (www.volusia.org.) that can be classified as Type I or II scrub-jay habitat (Fitzpatrick et al. 1991) as well as aerial photographs on which the white, sandy soils associated with scrub-jay habitats forms a distinctive signature.

Quantifying Demography

I established study years for the purpose of quantifying demography beginning 1 April and ending 31 March following Breininger et al. (1996), creating two and one half study years. Juveniles were defined as young observed in July (Woolfenden and Fitzpatrick 1984). I calculated mean family size in July to reflect the number of juveniles present.

For each study year, I noted the number of juveniles, yearlings (second year nonbreeders), older nonbreeders, and breeders for all territories in the study area. I assumed all scrub-jay breeders who disappeared and whose mate paired with another were mortalities, as divorce is infrequent (Woolfenden and Fitzpatrick 1984). I also assumed that all juveniles who went missing from their natal territory were mortalities, since Florida scrub-jays usually delay breeding for at least one breeding season after hatching and have short dispersal capabilities (Woolfenden and Fitzpatrick 1984). I produced juvenile survival values for each territory by taking the number of juveniles produced and subtracting the number of juveniles that did not become yearlings. Territories for which juveniles were never observed were given a juvenile survival value of 0. I did not examine fledgling survival due to my inability to locate every nest in the study area. I produced breeder survival values for each territory by representing the percentage of breeders that survived, creating three breeder survival values: 1 (meaning both breeders survived), 0.5, and 0. The disappearance of second year nonbreeders and older nonbreeders was documented as apparent mortality but not true mortality due to the availability (albeit limited) of scrub habitat outside of the study area.

I calculated demographic performance in each territory for Study Years 1 and 2 by subtracting the number of breeders that died from the number of yearlings produced (Breininger 1999). The production of yearlings was used to represent recruitment for these purposes because yearlings can breed and are the source from which new breeders come (Breininger 1999). Negative demographic performance for a territory suggested that the territory was a sink, while positive performance suggested the territory was a source.

I calculated Florida scrub-jay density for each year by summing the territory size for all territories in the study area and representing that number as the number of pairs of scrub-jays per 40 ha (Breininger and Oddy 2004). Florida scrub-jay density was defined for each management phase by counting each territory that contributed to the density of each phase for each study year and representing the number of pairs per 40 ha (Breininger and Oddy 2004).

Differences Between Study Years and Management Phases

I calculated average territory size, family size, demographic performance, no. of juveniles per pair, no. of yearlings per pair, juvenile survival, and breeder survival for each study year (where applicable) by summing the values for each territory and dividing by the number of territories. I calculated means separately for each year because population density varied annually (Breininger and Oddy 2004). For differences between management phases, only territories that were completely contained within Phase 1 and Phase 2 were used to create means for the demographic measurements for each study year.

I used Mann Whitney U and Kruskal Wallis Tests to examine differences between study years that represented different densities since some territories were represented in both, if not all, study years and therefore were not independent values. For yearly differences between demographic values for territories in Management Phases 1 and 2, I used a one-way ANOVA. For those values that were not homogeneous a transformation was performed. In the case that a transformation could not make the data homogeneous, Mann Whitney U tests were performed.

Demographic Consequences of High Densities

I used territory size as an indicator of density and assumed that territory size would decline with increased density due to the discrete suburban boundaries of the study area. I used a one-way ANOVA to examine differences between the mean of territory sizes of those territories that persisted and those that became extinct between study years 2 and 3. Combining study years 1 and 2 using Mann Whitney U and Kruskal Wallis Test I examined for differences between mean territory size and demographic performance, as well as the variables that contribute to demographic performance (breeder survival and yearling production). I then graphed territory size vs. these variables if a relationship existed. I used SPSS regression to examine whether the number of jays per family significantly affected territory size in Lyonia. Combining all data across all study years I used Mann-Whitney U Test to examine differences between Florida scrub-jay juvenile production for pairs with and without helpers.

RESULTS

Response to Habitat Management

Survey results for Study Year 1 revealed a maximum of 161 individual scrub-jays in July comprised of 34 families within the Preserve with a population density of 10.07 pairs / 40ha (Table 2). During Study Year 2 the population increased to a maximum of 180 individual scrub-jays in 45 families. Population density also increased to 12.77 pairs / 40ha. Although one family was located in Phase 3 during this time they were observed to only be utilizing the edges of the timbered areas. Birds were, however, observed flying across the road that separates Phases 1 and 2 from Phase 3. Between Study Years 1 and 2, 12 new territories were formed and one territory was lost. In 2006 (after Study Year 2) the population declined to 127 individual scrub-jays in 34 families. Population density declined to the lowest levels observed during the study period to 7.82 pairs / 40ha. During this time almost all of the timbered area in Phase 3 was being utilized for habitat by scrub-jays. Figure 3 illustrates the population dynamics of Florida scrub-jays at Lyonia Preserve from the onset of habitat management to the end of the study period. Between Study Years 2 and 3, two new territories were formed and 13 were lost.

I observed fluctuating scrub-jay numbers during monthly surveys of the non-breeding season (July – the beginning of March) of Study Year 1, ranging from 161 individuals in July 2004 to 99 individuals in September 2004 (Figure 4). Eight individual scrub-jays went missing for a period of time only to return to their original territories. Two of those eight were missing for over a year before returning to their original territories. All banded scrub-jays were accounted for during the surveys in November 2004 following the extreme hurricane season. No road mortality of scrub-jays was documented during my study.

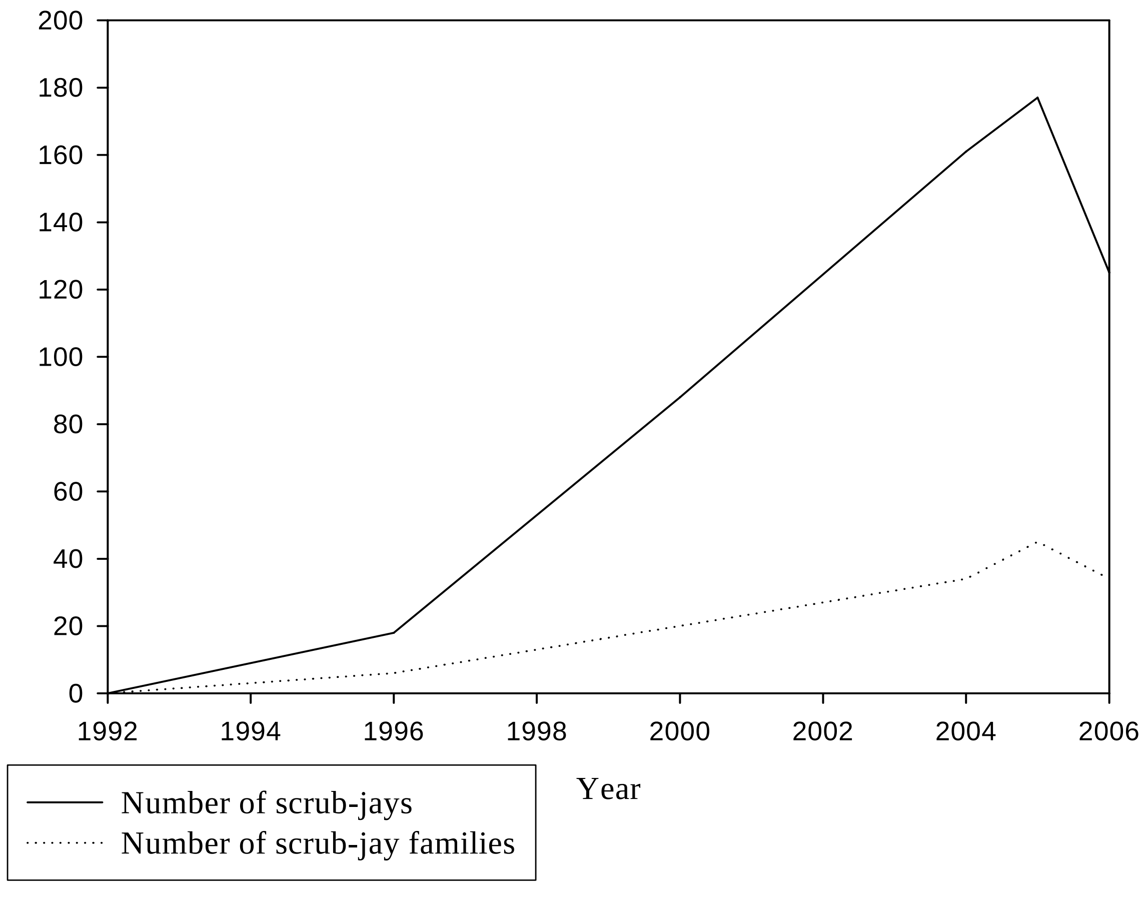

Figure 3: Number of Florida scrub-jay individuals and families from pre-habitat restoration through the study period (see “Methods” for habitat management dates) at Lyonia Preserve, Deltona, Florida.

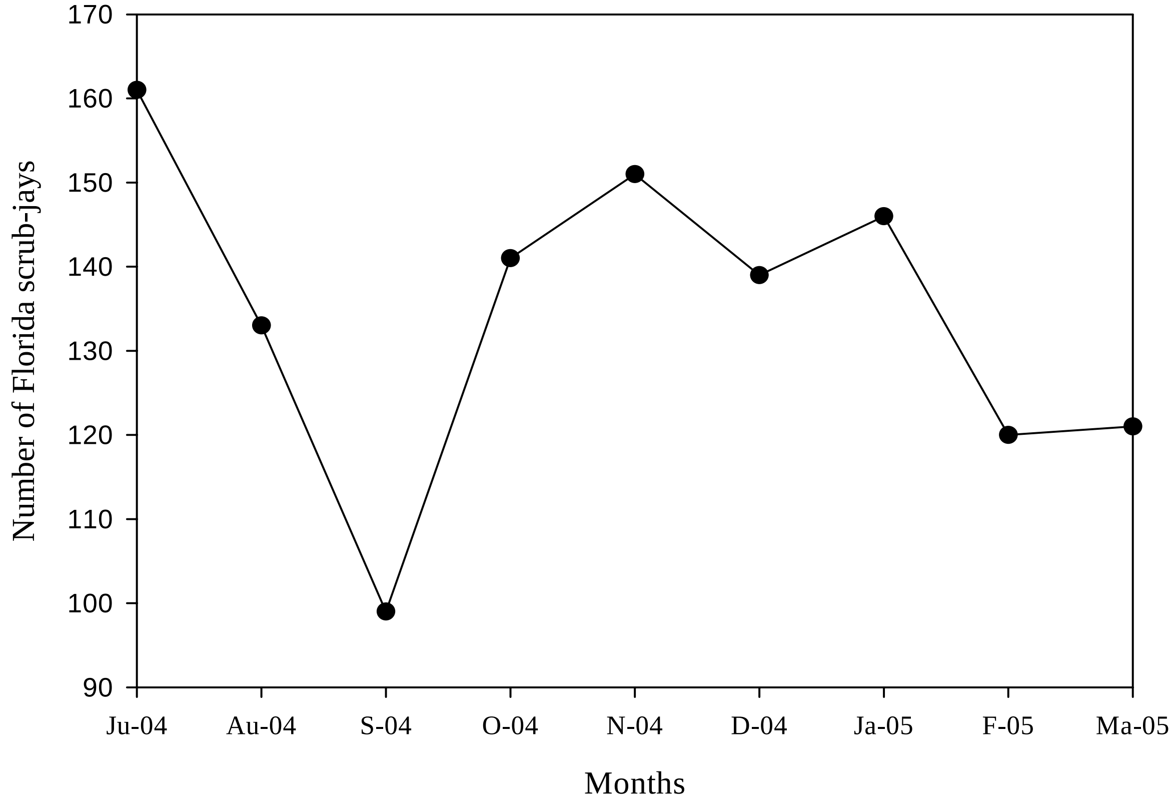

Figure 4: Nonbreeding season population dynamics of Florida scrub-jays at Lyonia Preserve, Deltona, Florida, during Study Year 1.

Territory Characteristics

All Florida scrub-jay territories overlapped well-drained ridges of sand-pine scrub as well as either trails, fire breaks, or unpaved roads (Figures 5 - 7). Territories were generally contiguous and often spread into roads, suburban developments, and neighboring schools. The powerlines adjacent to Lyonia Preserve also provided habitat for territories. The depressional wetlands (2) found on the site generally provided for territorial boundaries, as no scrub-jays were observed flying over them except in cases of dispersal. Territory size was variable from year to year, despite that from Study Year 1 to Study Year 2 no additional habitat was created. Territories that were situated in the newly managed habitat in Phase 3 were much larger than the territories in Phase 1 or 2; however, sample size was not large enough to draw any significant conclusions.

Phase 3 had the greatest amount of habitat management during the study period, followed by Phase 1, Phase 2, and the powerlines, respectively (Table 1). Results of territory evaluations based on spot checks of two randomly chosen territories within Phase 1 and 2 are shown in Table 2. The two representative territories from Phase 1 had higher Habitat Suitability Index (HSI) values than the territories from Phase 2.

Table 1: Habitat management type, location, and area (in ha) in Lyonia Preserve, Deltona, Florida.

Management Technique	Location of Management Phase 1	Phase 2	Phase 3	Powerlines
Roller Chop	9.9	1.1	n/a	n/a
Oak Islands/ Stripping	12.9	5.0	n/a	7.2
Sand Pine harvest/timber	n/a	5.2	32.5	n/a
Total Amount (ha)	22.8	11.3	32.5	7.2

Table 2: Habitat Suitability Index (HIS) values of two randomly selected territories in Phases 1 and 2 in Lyonia Preserve, Deltona, FL.

Variable	Phase 1		Phase 2	
	Territory 1	Territory 2	Territory 1	Territory 2
% scrub oak cover	50.00	68.75	46.88	50.00
% pine cover	6.25	< 1.00	25.00	31.25
% open space	28.13	21.88	6.25	9.38
Average shrub height (m)	2.2	2.1	1.9	2.1
HSI values	.88	.88	.64	.62

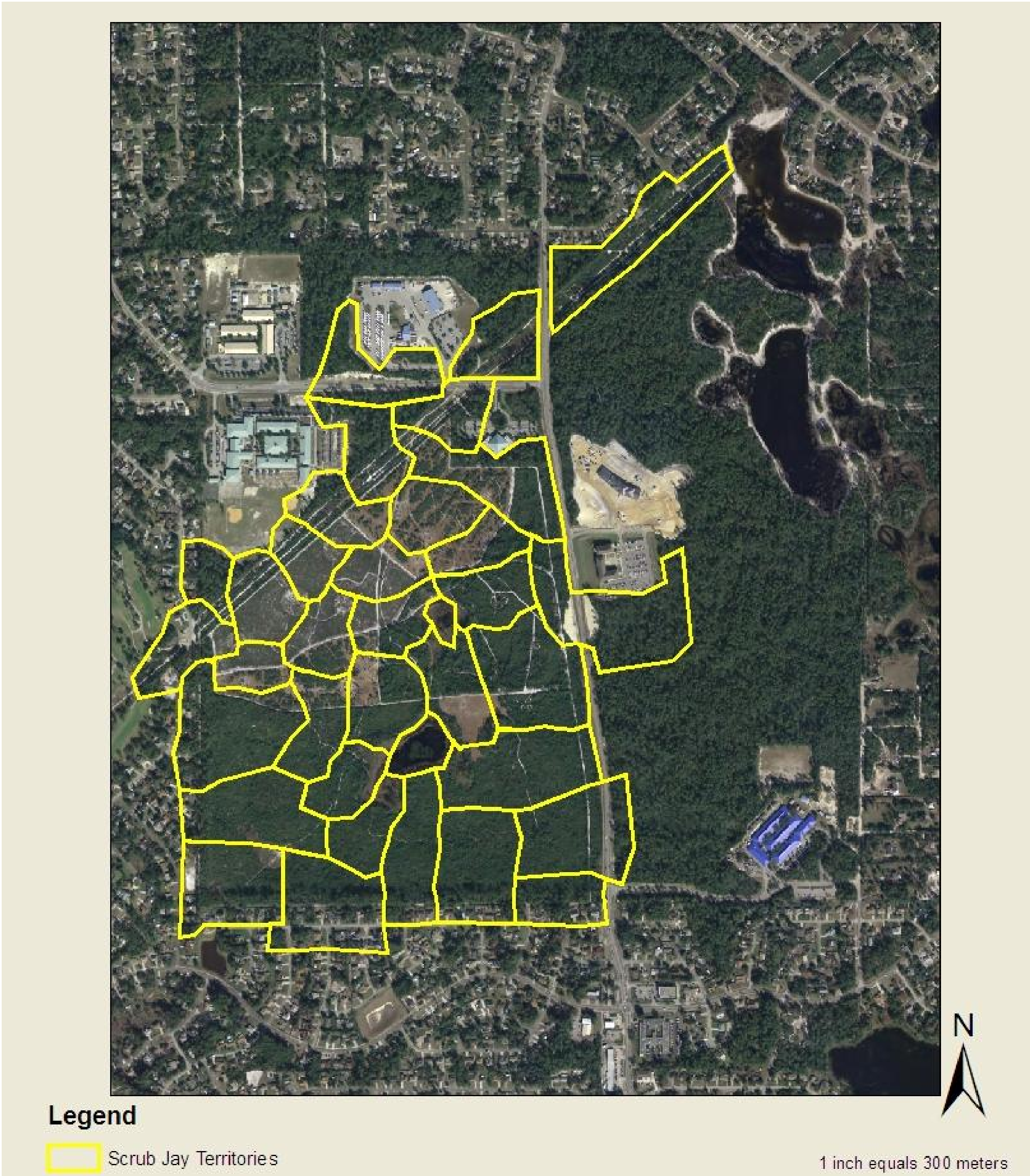

Figure 5: Florida scrub-jay territories during Study Year 1 (2004), Lyonia Preserve, Deltona, Florida.

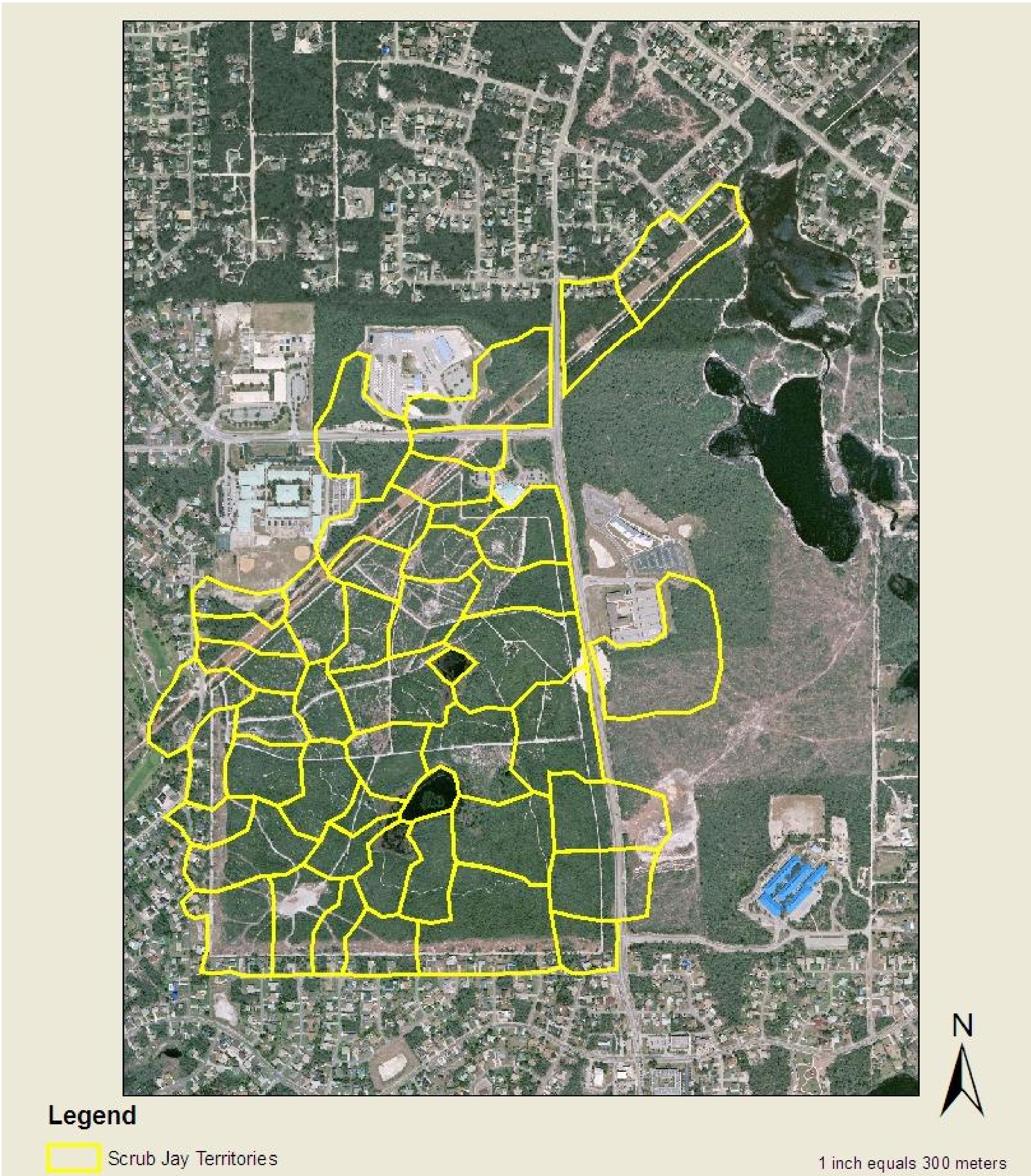

Figure 6: Florida scrub-jay territories during Study Year 2 (2005), Lyonia Preserve, Deltona, Florida.

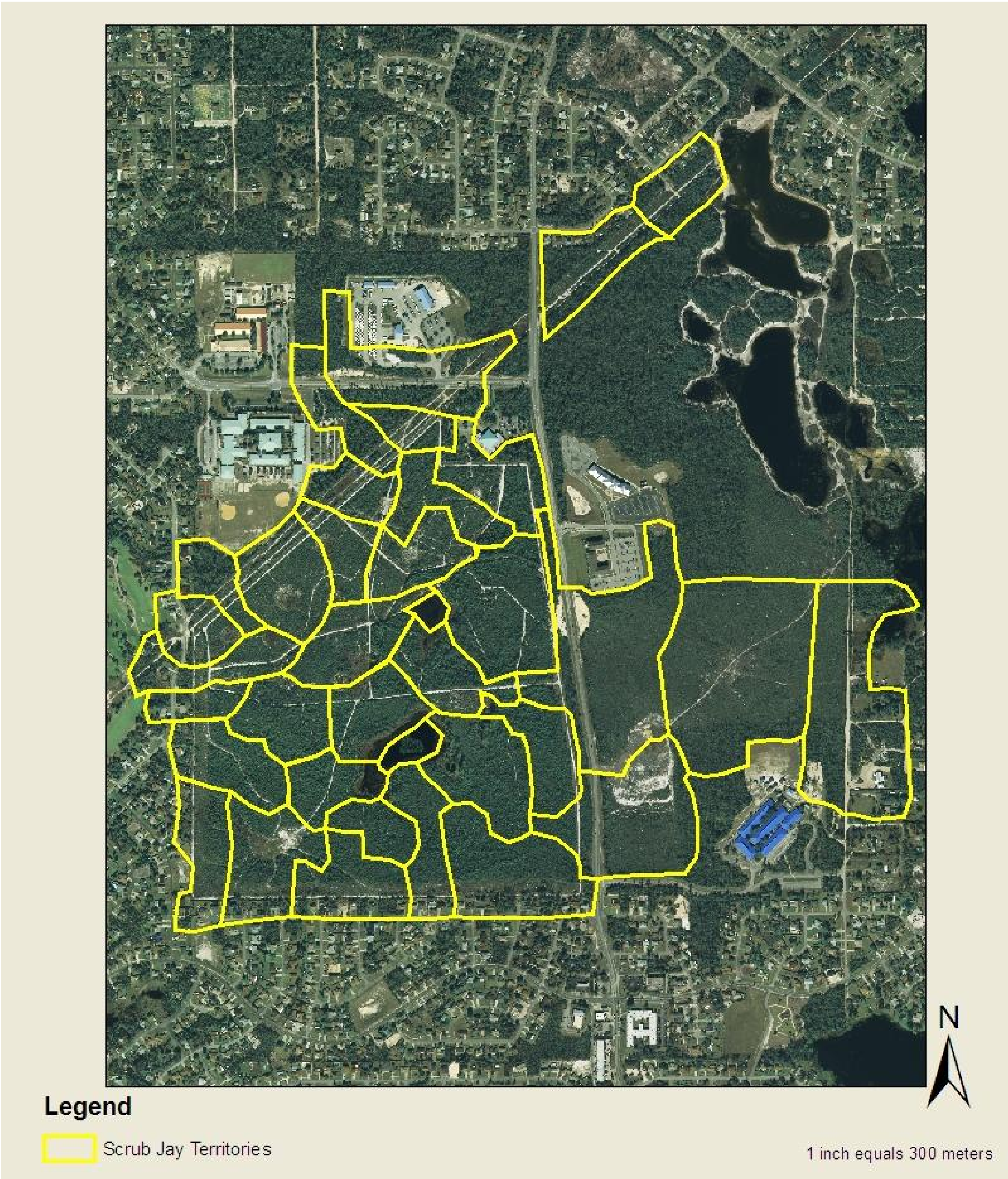

Figure 7: Florida scrub-jay territories during Study Year 3 (2006), Lyonia Preserve, Deltona, Florida.

Demography

During Study Year 2 territory size, demographic performance, and breeder survival were significantly lower than in Study Year 1 (Table 3). Territory sizes during Study Year 2 were significantly smaller than those in Study Year 1 and 3 ($p=.009$, MWU=500.500 and $p<.001$, MWU=404.500, respectively). There was no significant difference in territory sizes between Study Years 1 and 3 ($p=.151$, MWU=461.000); however, mean family size was significantly different between these years ($p=.037$, MWU=450.000). I observed significantly smaller territories between Management Phases 1 and 2 during Study Year 1, but not in Study Year 2 (Table 4). Mean family size varied between years and phases, but was only significantly different during Study Year 2 between Phase 1 and 2.

Table 3: Florida scrub-jay demographic differences between study years at Lyonia Preserve, Deltona, FL.

Variable	Study Years			Kruskal Wallis or Mann Whitney	
	Year 1 (10.07 pairs/40ha)	Year 2 (12.77 pairs/40ha)	Year 3 (7.82 pairs/40ha)	Chi Square or U	P
Territory size (ha)	3.96 ± 1.52	3.13 ± 1.48	5.12 ± 3.23	14.93	.001
Family size	4.74 ± 1.81	4.07 ± 1.84	3.82 ± 1.77	5.14	.077
Demographic performance	.44 ± 1.08	-.64 ± 1.33	No data	199.500	.003
# juveniles/pair	1.41 ± 1.40	1.07 ± 1.27	.82 ± 1.06	3.38	.185
# yearlings/pair	.68 ± .77	.38 ± .72	No data	291.00	.114
Juvenile survival	.40 ± .45	.21 ± .38	No data	293.000	.123
Breeder survival	.88 ± .28	.49 ± .46	No data	189.000	<.001

Table 4: Florida scrub-jay demographic differences between Management Phases 1 and 2 at Lyonia Preserve, Deltona, FL.

Variable	Year 1		Anova		Year 2		Anova	
	Phase 1 20.74 pairs/40ha	Phase 2 11.64 pairs/40ha	F	P	Phase 1 23.70 pairs/40ha	Phase 2 16.29 pairs/40ha	F	P
Territory size (ha)	2.95 ± .88	4.45 ± 1.45	9.274*	.006*	2.68 ± 1.18	2.94 ± 1.64	.272	.606
Family size	5.13 ± 1.77	4.78 ± 2.39	.175	.680	4.94 ± 1.82	3.46 ± 1.94	4.600	.041
Demographic performance	.53 ± 1.30	.22 ± .67	.439	.515	-.41 ± 1.62	-.69 ± 1.03	.296	.591
# juveniles per pair	1.87 ± 1.51	1.22 ± 1.64	.964	.337	1.53 ± 1.12	.85 ± 1.46	2.097	.159
# yearlings per pair	.87 ± .92	.11 ± .33	5.597***	.027***	.65 ± .93	.31 ± .48	1.427	.242
Breeder survival	.83 ± .31	.94 ± .17	.968**	.336**	.47 ± .48	.54 ± .48	.147	.704
Juvenile survival	.40 ± .44	.11 ± .33	2.912	.102	.30 ± .41	.17 ± .37	.824	.372

* indicates analysis performed with log transformed data
** indicates analysis performed with square root transformed data
*** indicates data which MWU did not agree with results of ANOVA

Territory Size and Demography

Mean territory size was not significantly different between territories with different demographic performance values calculated during Study Years 1 and 2 (p=.125, Chi-Square= 8.625), despite appearing to have a linear relationship with an increase in territory size leading to an increase in demographic performance (Figure 8). Mean territory size was different between territories with different breeder survival values during Study Years 1 and 2 (p=.05, Chi-Square= 5.995). Further examinations revealed that family groups with 100% breeder survival had significantly larger territories than those with 0% breeder survival (p=.017, MWU=307.000 mean of those with 100% survival = 3.45 ±1.55 ha and of those with 0% survival = .69 ± .47 ha).

Figure 9 illustrates this relationship with a linear regression, with breeder survival increasing with increasing territory size. Mean territory size was not significantly different between territories with different yearling production values calculated during Study Years 1 and 2 ($p=.350$, Chi-Square= 3.283). Territory size was not significantly related to the number of adults or total number of jays per family ($p=.890$, $n=112$).

Juvenile production was significantly greater with the presence of helpers for Study Year 1 but not for Study Years 2 and 3 ($p=.016$, $F=6.450$ for Year 1; $p=.088$, $F=3.056$ for Year 2; and $p=.577$, $F=.317$ for Year 3). One territory that was present in Study year 1 disappeared in Study year 2 and therefore sample size was too small to examine for any significance. Territory persistence was significantly more likely for territories of greater size between Study year 2 and 3 ($p = .018$, $F = 6.057$) (mean of those that persisted = 3.5 ± 1.5 ha and of those that disappeared = $.8 \pm .4$ ha). Of the territories that went extinct between Study Years 2 and 3, seven were newly formed and six were established territories in the first study year. An equal amount of territories were lost between Phase 1 and 2 (5 and 5, respectively).

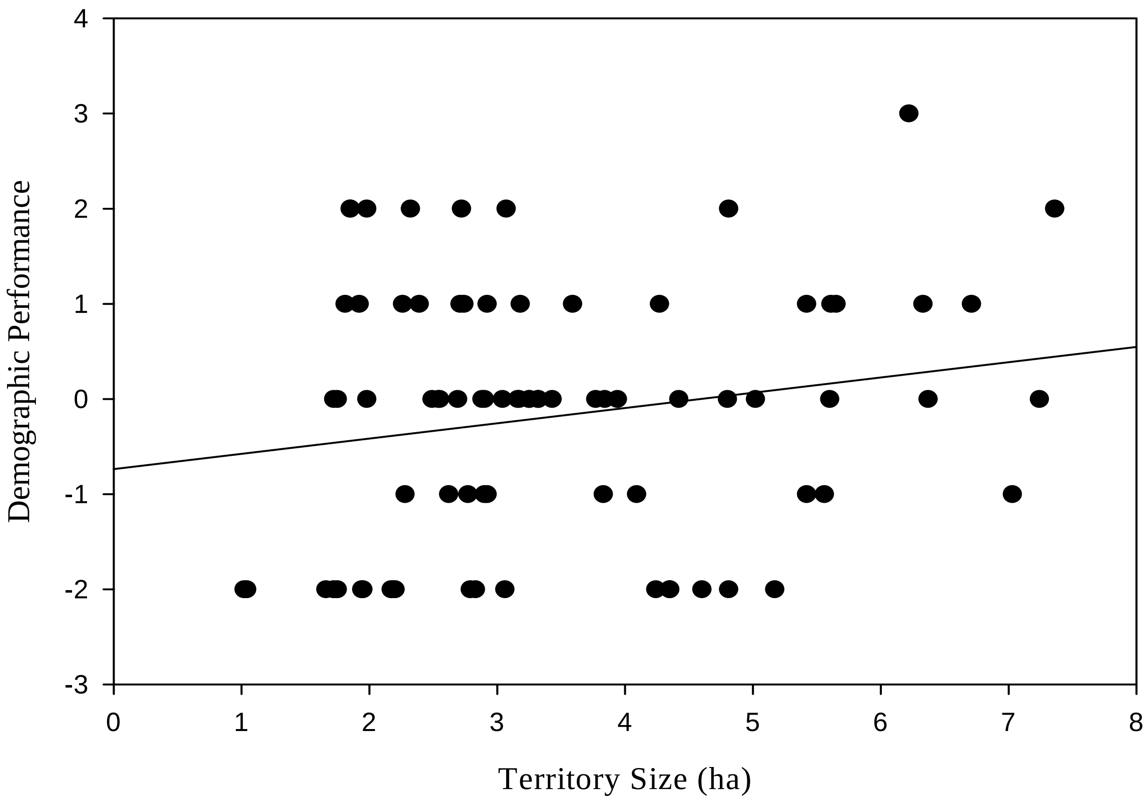

Figure 8: Demographic performance vs. territory size for Florida scrub-jays at Lyonia Preserve, Deltona, Florida, during Study Years 1 and 2.

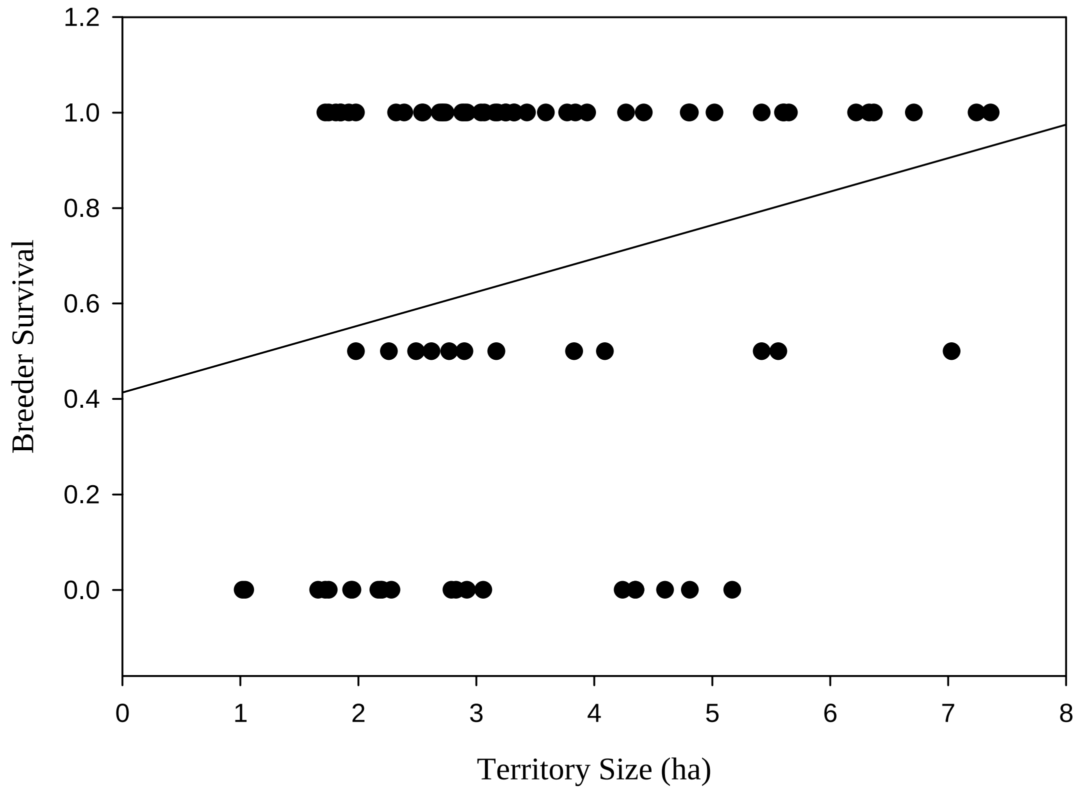

Figure 9: Breeder survival vs. territory size for Florida scrub-jays at Lyonia Preserve, Deltona, Florida, during Study Years 1 and 2. The line represents the least squares fix to the data.

Relationships to Other Scrub-jay Populations

I observed a total of 32 dispersal events within and outside of the Lyonia population. Figure 10 shows the frequency of dispersal separated by sex for each bird during the study years. Females traveled significantly farther than males ($p = .009$, $F = 7.692$, mean of square root transformed data = 2.815, mean of non-transformed data = 8.625 km). No effective dispersal between the three other large groups (Lake Monroe Conservation Area and Blue Springs State Park) occurred during the study period. These populations are separated from Lyonia Preserve by a distance of approximately 12km. The furthest observed dispersal event involved a female scrub-jay crossing at some point over Interstate 4, which separates Lyonia Preserve from Blue Springs State Park.

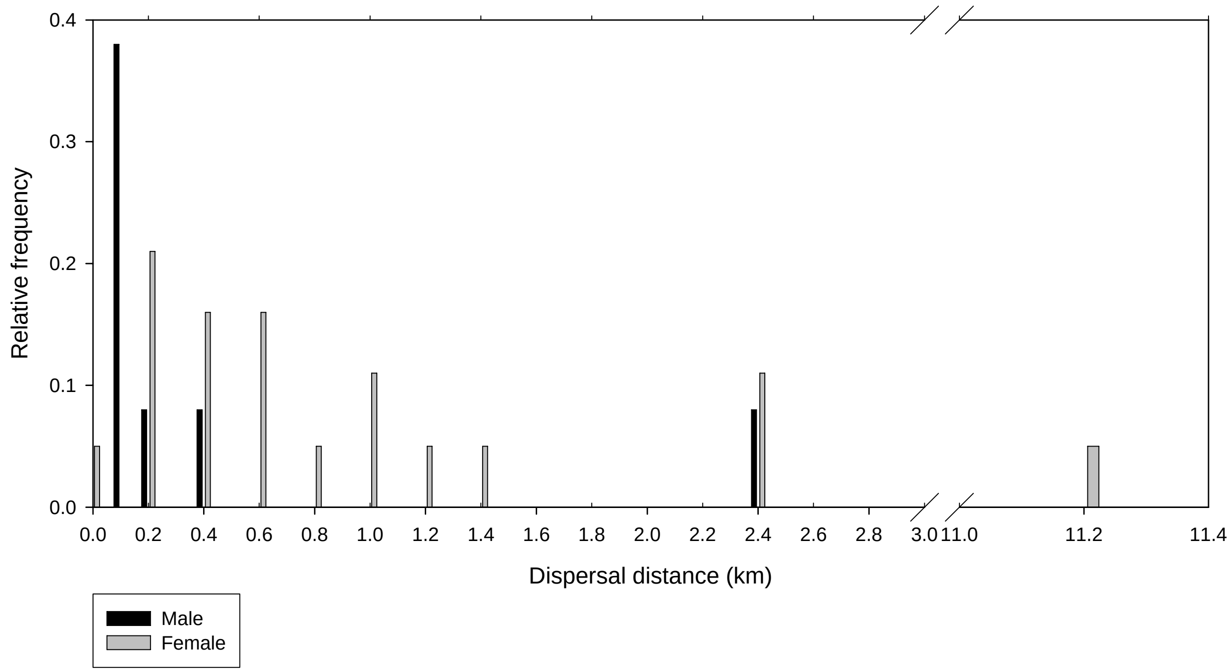

Figure 10: Frequency of dispersal of male and female Florida scrub-jays out of Lyonia Preserve, Deltona, Florida.

CONCLUSION

Habitat and Demographic Characteristics of Territories

Atypically high densities of Florida scrub-jays observed in my study on the Lyonia Preserve were the result of large family sizes on tightly compressed territories. Both family size and territory size are exceptional relative to those reported for other studies (e.g., Woolfenden and Fitzpatrick 1984 and Breininger et al. 1996). Generally Florida scrub-jay territories are large (10 ha) and often comprised of largely unsuitable habitat (Duncan et al. 1995). The territories at Lyonia do not follow this model and are almost entirely comprised of suitable habitat completely situated on sand pine scrub ridges.

The significant decrease in size for territories in the more heavily managed Phase 1 during Study Year 1 suggests that, as predicted, frequent habitat management may support higher densities of scrub-jays at Lyonia Preserve. This trend in territorial behavior is not a recent phenomenon at Lyonia Preserve as Epperson and Romogosa (2001) also found that scrub-jay territories in the more heavily managed Phase 1 were smaller than in Phase 2. Other studies have shown that scrub-jay densities vary directly with habitat quality, with territories in poorer habitat tending to be larger than those found in better quality habitats (Woolfenden and Fitzpatrick 1991) and territories with mixed heights (small to tall) of oaks tending to support higher scrub-jay densities (Breininger and Carter 2003). Evaluations of territories indicate that Phase 1 territories had a higher HSI for scrub-jays (Breininger 1992), with less pine cover and more open space. When differences between territory sizes in Phase 1 and 2 were no longer significant, mean family size in Phase 2 dropped. The most obvious explanation for the change in family size is a reduction in habitat quality. No other significant demographic differences occurred between the management Phases, indicating that the rest of the demographic trends observed were likely a preserve-wide phenomenon and not limited to the management phases.

Although scrub-jay densities showed a strong response to habitat management, I could not accept or reject the prediction that the observed high densities could be completely attributed to habitat management. Although not detected, individuals may still be packing into Lyonia Preserve due to habitat destruction and consequently also contributing to higher densities. This crowding effect may be rapid and result in super-saturation of the remnant (Saunders et al. 1991) as was observed with the rapid colonization of Lyonia Preserve post habitat restoration (Figure 3), with the extent of crowding related to the number of refugees and the area of available habitat to absorb them (Lovejoy et al. 1986). If immigrants did escape detection due to the number of unbanded individuals, and assuming active habitat selection by scrub-jays for the highest quality habitat available (Pulliam 1988, Pulliam and Danielson 1991), Phase 1 appeared to be the optimum choice for colonization with higher HSI values (Table 2).

The increase in juvenile production for scrub-jay groups with helpers in Year 1 agreed with other Florida scrub-jay demography studies (e.g., Woolfenden and Fitzpatrick 1984, Mumme 1992, Breininger et al. 1996). The presence of helpers increases the amount of food delivered to each fledgling, possibly decreasing the likelihood of starvation, and also increases the likelihood of detecting threats from predators (McGowan and Woolfenden 1990). This relationship was not observed in Study Years 2 and 3. The higher densities observed in Study Year 2 from Study Year 1 may have contributed to this lack of relationship. Because scrub-jays have a well developed sentinel system for detecting predators (McGowan and Woolfenden

1989), scrub-jay families whose territories are partially surrounded by other territories may derive a benefit of safety from this system (Breininger 1999). Although densities declined in Study Year 3, the drought during the breeding season at that time may have masked any contribution by the helpers, since increasing rain amounts have been demonstrated to increase the proportion of nests producing at least one fledgling (Woolfenden and Fitzpatrick 1984). Access to supplemental food also tends to make the jays breed earlier than the appearance of arthropods in the later months of the spring season (Bowman et al. 1999), and the lack of rain may have decreased the arthropod supply for the juveniles. Juvenile production was lowest (although not significantly) during Study Year 3.

Carrying Capacity

The response of Florida scrub-jays on the Lyonia Preserve is consistent with observations of diverse organisms to restored ecological communities. Generally population changes are characterized by very dynamic temporal changes resulting from colonization events (Montalvo et al. 1997). The graphical representation of population growth in Lyonia Preserve resembles classic density dependence, with the carrying capacity of this habitat having some relationship to habitat management. It is unknown how much of this growth can be attributed to immigration of scrub-jays into Lyonia Preserve since population density often increases on habitat fragments (Debinski and Holt 2000), recruitment in the form of yearling production, or both since detailed demographic studies were not performed at the time of initial colonization.

Carrying capacity for this habitat, calculated by mean territory size divided by the area of total available suitable habitat (Breininger et al. 1999), is much higher than 14 scrub-jay groups (approximately 140 ha. total habitat available in Phases 1, 2, and 3 of Lyonia Preserve divided by mean territory size of 10 ha, Woolfenden and Fitzpatrick 1984, Woolfenden and Fitzpatrick 1991, Breininger et al. 1995), since the population was still growing when 20 groups occupied Lyonia Preserve on an average of 5 ha per group (Epperson and Romogosa 2001). Again, although habitat management did appear to increase carrying capacity, it is unknown how much this population growth could be attributed to crowding. Greenburg et al. (1995) found that generally sand pine scrub vegetation responded similarly to high intensity silvicultural disturbance (such as roller chopping and root raking) as to natural disturbance by high intensity wildfires. Duncan et al. (1995) found that optimal scrub-jay territory occurred in areas 10-20 years post burn, making Lyonia Preserve right on that optimal edge and capable of supporting higher densities of scrub-jays. In Phase 1 (approximately 40 ha) during Study Year 1, the average territory size was just under 3 ha before the population began to experience a decline. Mean territory size for all territories associated with Lyonia Preserve was just over 3 ha when the population began to decline. Based on these results, it would appear that 4 ha represented a minimum territory size under the prevailing conditions, below which demographic viability is lost.

Carrying capacity at Lyonia Preserve may be also have been artificially raised by supplemental feeding of scrub-jays by the public, both in the form of increased resources and in behavioral alterations. Bednekoff and Woolfenden (2006) found that scrub-jays increased sentinel behavior when given supplemental food, affording greater protection against predators and potentially increasing survival. Although I did not actively monitor all the nests during the study, there was no significant difference in juvenile production among the three study years.

The creation and subsequent occupation of suitable habitat in Phase 3 during the end of Study Year 2 should have raised carrying capacity for Lyonia Preserve since new scrub-jay groups are often formed in restoration areas (Stevens and Knight 2004). Of the 14 new territories that were formed during the course of this study, only 2 were in the newly restored Phase 3. Although not measured, the drought experienced in Study Year 3 may have led to a decline in resources as other studies (e.g. Moyer et al. 2007) have reported on acorn mast failures during periods of drought. High rainfalls in previous years may have also raised carrying capacity to levels that were not stable in the long run by increasing resources so that (1) more alternate food sources are available for predators and (2) decreasing the amount of time searching for food and increasing the available time for predator detection (Woolfenden and Fitzpatrick 1984).

Metapopulation Dynamics

Although I was not able to document colonization of Lyonia Preserve, destruction of habitat outside of the preserve, both in the form of patches of source or sink habitats may have initially created the observed high densities. The results of my study suggest Lyonia Preserve functions as a source during Study Year 1, more specifically a pseudo-source during the growth phase with positive demographic performance despite the crowding effect. These high densities were potentially stabilized by the presence of habitat patches outside the preserve where back-dispersal may have resulted in the total population size being higher than the carrying capacity of an isolated system (Dias 1996). With the intrinsic positive growth observed during Study Year 1 and the loss of outside habitat patches, the preserve then began to function as a pseudo-sink (Watkinson and Sutherland 1995), with the local population size increasing above carrying capacity during Study Year 2 and thus creating negative demographic effects at the realized high density (Dias 1996).

The southwest Volusia County scrub-jay population appears to continue to be made up of a series of midlands (10-99 pairs) and islands (<10 pairs) (Stith et al 1996), with the Lyonia Preserve population replacing the extirpated Stewart Ranch population (NeSmith et al. 2004) and providing a refuge for small populations displaced by development in Deltona. Although urban scrub-jays often have longer dispersal distances than for those found in continuous habitat (Breininger 1999), this was not observed during the course of my study and may be both a reflection of habitat loss outside of Lyonia Preserve as well as the time frame of my study. Connectivity between these populations seems limited, as no dispersal between the midlands was observed. Further research is needed to determine if the southwest Volusia County metapopulation (Stith et al. 1996) is now separated into three isolated populations.

Thaxton and Hingtgen (1996) found that jays dispersed from fragments to large tracts of scrub but not vice versa. A major limitation of my study is that I am not able to document where the adults who were already occupying the preserve originally came from, although I hypothesize that they came from local habitat fragments because the site was unoccupied prior to habitat restoration. However, during my study I only observed emigration, with the few successful dispersal events consisting of scrub-jays leaving Lyonia to inhabit marginal habitat along powerlines and in urban areas. Scrub-jays banded outside of and within dispersal distance of Lyonia Preserve were never observed on the property, although this may be a sample size issue as only nine individuals fall into this category. The fluctuating numbers illustrated during the non-breeding season of Study Year 1 are changes in birds previously observed inhabiting Lyonia. It is possible that some unbanded scrub-jays escaped detection and did in fact disperse into Lyonia, replacing other unbanded individuals in the population. In both cases, this suggests Lyonia Preserve is currently functioning as a "leaky" system (Dias 1996) with immigration and emigration currently ongoing. As habitat destruction continues, this system may become closed.

Consequences of High Densities

As predicted, higher densities resulted in smaller territory areas. Breeding territories generally limit the number of individuals found in a particular habitat and therefore may be central to population regulation (Ridley et al. 2004). In the case of scrub-jays at Lyonia Preserve, territories became compressed (Ridley et al. 2004) as population densities increased. Smaller territory size had a significant negative effect on demographic performance, specifically breeder survival, but not yearling recruitment, contrary to other scrub-jay studies on urban fragments (e.g., Breininger et al. 1996 and Breininger 1999) and bird studies (e.g., Luck 2003). Lower survival of breeders experiencing high as opposed to low densities could be explained by a lack of resources, although scrub-jays don't usually starve (Woolfenden and Fitzpatrick 1984). Differences in breeder survival more likely resulted from habitat specific vulnerability to predators (Breininger and Oddy 2004), with the increase in density creating more territorial disputes and therefore making scrub-jays more visible to predators. Further research is needed to determine if any diseases also contributed to the observed high breeder mortality during the period of highest population density (Study Year 2).

During the period of population decline (Study Year 2), territories that persisted from one year to the next were significantly larger than those that went extinct. These results must be interpreted cautiously, because territories that are newly created tend to be smaller than existing territories (Woolfenden and Fitzpatrick 1984), with only a small fraction of the new groups persisting for long periods (Stevens and Knight 2004). However, these results do support the argument made in earlier sections that mean territory size at carrying capacity for scrub-jays at Lyonia may fall around 4 ha.

Increased density of scrub jays also increased the number of territories adjacent to roads and/or residential areas. Figure 11 shows the location of territories that experienced breeder loss during Study Year 2. Fifteen territories that bordered roads experienced breeder loss, while 13 were interior territories. During Study Year 2 the sand pine buffer around Phase 2 was removed, potentially exposing the jays to more predators. One confirmed mortality of a female breeder whose territory bordered a residential area was caused by a house cat (FFWCC Enforcement pers. comm..). Although efforts to manage habitat along the urban interface to enhance demographic success could allow these territories to function as sources under optimal conditions (Breininger et al. 2006), these actions may also create higher rates of predation than in a wildland habitat (Vierling 2000). No road mortality was ever observed, though this may be an artifact due to (1) my inability to search the roads regularly for evidence of road kill and (2) the lack of detection of road kill due to scavengers and scrub-jays becoming lodged in vehicles (Mumme et al. 2000).

Figure 11: Location of Florida scrub-jay territories that experienced breeder loss between Study Years 2 and 3, Lyonia Preserve, Deltona, Florida.

Conservation Implications

Efforts to maintain the integrity of natural communities are bringing ecosystem management to the forefront of conservation biology (Greenburg et al. 1995). Habitat restoration often occurs on unoccupied sites, and therefore research conducted on these sites is relevant to understanding the factors that influence colonization, growth, and distributions of populations (Montalvo et al. 1997). Results of this type of research are often limited to the patch scale and must be extrapolated to larger scale with caution. These studies may obscure or exaggerate regional declines that are now occurring for many species (With and King 2001). Occupancy data on these sites may not predict long-term abundance, especially if crowding of individuals is observed because it may produce higher occupancy rates than would be expected under stable conditions (Lamberson et al. 2000). However, measuring the effectiveness of protected areas is essential to ensure that key objectives, such as long-term viability of the species being managed, are being met (Turner et al. 2006).

It is important to understand both the deterministic factors that reduce population size, such as habitat loss, and the stochastic factors that lead to the final extinction of small populations when attempting to prevent extinctions of threatened species. Generally, cooperative breeders such as Florida scrub-jays are more vulnerable to catastrophic events of lower magnitude and frequency than their non-cooperative breeding counterparts (Courchamp et al. 1999). Fire suppression alone has been shown to facilitate local extinction of Florida scrub-jays, even in large populations (Root 1998). Factoring in environmental variability as a stochastic demographic variable can greatly raise the extinction risk even in large populations of Florida scrub-jays (Heino and Sabadell 2003). Breininger et al. (1999) predicted that populations of scrub-jays of 20 – 50 pairs were vulnerable to extinction within optimal habitat unless catastrophes, such as hurricanes, were rare. Although my study only lasted for two and a half years, the results indicate the impacts of drought on Florida scrub-jays may also be a potential catastrophe and require further study. In contrast, the lack of mortality from the hurricane events during my study indicates that these storms were not strong enough to constitute catastrophic events from the standpoint of scrub-jays. However, the drought that began in early 2006 coincides with declining numbers, not just numbers of individual scrub-jays but also numbers of family groups. It is unknown at this time if other populations have experienced sharp declines; however, past studies indicate that an epidemic swept scrub-jay populations during 1997 and 1998 (Stevens and Knight 2004, Breininger 1999), which were also periods of extreme drought in the state of Florida (Graumann et al. 1998).

Management objectives for scrub-jays tend to maximize the amount of recruitment by maximizing habitat quality (e.g. Breininger and Carter 2003, Stevens and Knight 2004), based on the notion that if local populations in a source habitat exceed the number of breeding sites available, the surplus individuals will be able to emigrate to achieve a higher level of fitness elsewhere (Pulliam 1988). However, the Lyonia birds have very little breeding sites available outside of the Preserve, and the sites that are within dispersal distance are not managed. In this case, emigration may result in lower fitness achieved outside of the preserve and therefore may be lacking, contributing to higher densities. The value of maximizing habitat quality through intense management of small patches may be reduced at this point due density-dependent regulation (McCoy and Mushinsky 2007), specifically through reduced scrub-jay breeder survival. Negative effects of management may be avoided by subjecting smaller areas to mechanical treatment with increased time between treatments (five to ten years). The length of breeding lifespan (and therefore breeder survival) has been found to be the most important component of total lifetime reproductive success for the Florida scrub-jay and relatively more important than offspring survival at any stage (Fitzpatrick et al. 1989). Any impact to breeder survival as a result of high densities could have long term negative effects on a species that is already undergoing a range-wide decline.

Should densities rise again to the Study Year 2 levels, the Lyonia Preserve population may be a good candidate as a source for translocation. Mumme and Below (1999) found that density decreased in a population of scrub-jays utilized for a source of translocation individuals. In that instance, a decline in population density was not wanted; however, in Lyonia's case it may be needed. Mumme and Below (1999) suggest using nonbreeders because nonbreeders had a higher (although not significantly) duration of residency than breeders.

In order to ensure the long-term viability of the population at Lyonia Preserve, connectivity with other midland and island populations must be restored. Single large scrub preserves are not necessarily better than many small patches (McCoy and Mushinsky 1994), and the purchase and management of patches of scrub outside Lyonia Preserve could provide refuges for surplus individuals as well as stepping stones to other populations. The powerlines along Lyonia Preserve that run through Deltona and into other areas of scrub habitat could provide corridors if they are managed effectively. This system of powerlines in southwest Volusia County eventually intersects with Blue Springs State Park, although no dispersal between these two populations has been documented so far. The longest dispersal event for a Lyonia scrub-jay (11 km) required the individual to cross Interstate 4, a major vehicular corridor and barrier.

At this time no mitigation banks have been approved for private development alternatives to an incidental take permit (Federal Registrar 2006), but the USFWS is expecting to change that rule (23rd Annual Growth Management and Environmental Permitting Short Course 2007). The results of this study indicate that through regular habitat management, demographic performance can be positive and carrying capacity can be raised for scrub-jays, therefore supporting a higher number of jays and creating a greater number of recruits than other, less-managed areas. This scenario should be implemented with caution, as isolated tracts of land that are highly managed and surrounded by landscapes with high rates of habitat destruction may create unusually high densities of scrub-jays. These lands may act as either pseudo-sources or pseudo-sinks and in the absence of immigration experience a population decline to some lower non-zero number (Dias 1996). Metapopulation theory should also be taken into consideration and regulatory officials should use caution when allowing for ”take” of Florida scrub-jay habitat as the effects may extend beyond the local habitat being destroyed in the form of crowding in another location.

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